controls the aircraft-band audio level, and the user should adjust it during quiet radio periods to minimize noise introduced into the entertainment audio program.

The TPA4411 integrates pop-noise-reduction circuitry, can drive as much as 80 mW into a typical headphone's 8 to 16Ω load, and operates over a power-supply range of 1.8 to 4.5V. Inductors L_3, L_4, and L_5 allow audio to pass unimpeded to the headphones and prevents the amplifier's outputs from shunting RF signals meant to be coupled to the receiver's resonant LC tank circuit.

To use the receiver, slowly adjust C_1 until you hear a pilot's communication in progress. Then, quickly tune C_1 to maximize the signal. The tuned circuit's selectivity is low enough such that, once you adjust C_1, it doesn't require retuning. Although you can use this receiver while awaiting your flight's boarding call, always ask permission from the flight crew before using the receiver aboard an aircraft. You can explain that the circuit does not interfere with the aircraft's navigation and communication systems. Airport-security personnel may regard any user-constructed electronic device with suspicion, however.

This receiver's sensitivity is low, and you generally hear only the pilot-to-ground side of two-way traffic. Fortunately, in controlled airspace, a pilot must repeat all commands so that air-traffic controllers can verify that the pilot clearly understood their instructions. Although a comprehensive survey of aircraft-band communications procedures is beyond the scope of this Design Idea, the following example explains certain terms.

While the aircraft remains at the departure gate, you typically hear a pilot repeating flight clearance, altitude restrictions, and other instructions—for example, "KLM 657 heavy, cleared for Amsterdam ... FL320 five minutes after departure. Departure frequency is 127.4, squawk 4312." "Heavy" means that the aircraft is a large jet, "FL320" means that the aircraft is cleared to fly at 32,000 feet, and "squawk" is the aircraft's four-digit identification number. To contact departure control, the pilot retunes the aircraft radio to 127.4 MHz. When the pilot enters the squawk into the aircraft's transponder, the flight controllers can identify the aircraft on-radar screens as KLM flight 657. Each time the aircraft enters a new segment of the taxiway on its way to the runway and again for takeoff clearance, the pilot contacts ground control to get taxi clearances.

Shortly after takeoff, the pilot contacts departure control: "KLM 657, radar contact, climb and maintain FL320, turn right heading 120, proceed on course." From then on, the pilot contacts flight controllers upon reaching predefined altitudes or when entering a different flight-control center's airspace. Approximately 30 minutes before reaching its destination, the aircraft begins its descent, and the pilot contacts approach control. Just before landing, you hear the final clearance: "KLM 657 heavy, winds 030 at 12, cleared to land runway 31."□

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Quickly estimate an electronic system's cooling requirements

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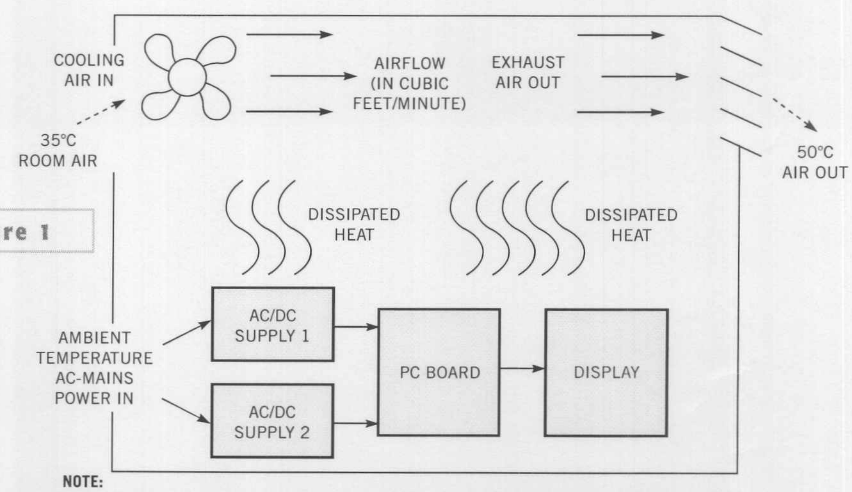
DURING NORMAL OPERATION, an electronic system generates wasted heat that can cause malfunctions and damage components unless you remove it. In an ideal world, you would have the time and resources to perform a rigorous evaluation of an electronic system's cooling requirements early in the design phase and thus avoid the cooling errors others have made in the past (**Reference 1**). However, circumstances often demand a diagnostic evaluation of a system's cooling methods or a rapid estimate of a proposed system's cooling requirements. For these purposes, you don't need an advanced degree in computational fluid dynamics; this Design Idea outlines a method that may be all that's necessary.

Figure 1 shows a typical cabinet-mounted electronic system that includes

Figure 1



To estimate a system's cooling requirements, you can simplify the thermal model to comprise an ac-power input and a dissipated-heat output.

two power supplies, a pc board, and a display. For simple products, you can assume that all of the power entering the cabinet from the ac power line ultimately converts into heat that dissipates within the cabinet. After you calculate the system's ac and dc power requirements, you can estimate the amount of power that the cooling method must dissipate. As a rule of thumb, the thermal capacity of air is 0.569W-minute/°C/ft^3 (**Reference 2**). That is, one cubic foot per minute of moving air can transfer 0.569W of dissipated heat for a 1°C temperature change. You can also express this rule as its reciprocal: To dissipate the heat 1W of power produces and maintain a 1°C temperature change, you need to provide an air stream of 1.757 cfm (cubic feet/minute). Thus, once you determine the wattage dissipated within a system and specify an allowable internal temperature rise, you can estimate a cooling fan's required air-movement capacity rating in cubic feet/minute.

However, a cooling fan's maximum rating in cubic feet/minute occurs only at zero static pressure, or back pressure, an operating condition that you don't realize in practice. You derate the fan's air-movement ability based on either measurements or estimates of the back pressure in the system's cabinet. (A manometer-style gauge measures air-pressure differentials in units of inches of water—that is, the height in inches of a column of water supported by the difference between ambient air and pressurized air within an enclosure.) For example, a manometer might display a pressure differential of 0.10 to 0.15 in. of water across a mostly clogged dust filter. When you plot the pressure versus airflow-volume curve for a typical 100-cfm fan, this pressure differential might reduce the fan's airflow volume to only 50 cfm.

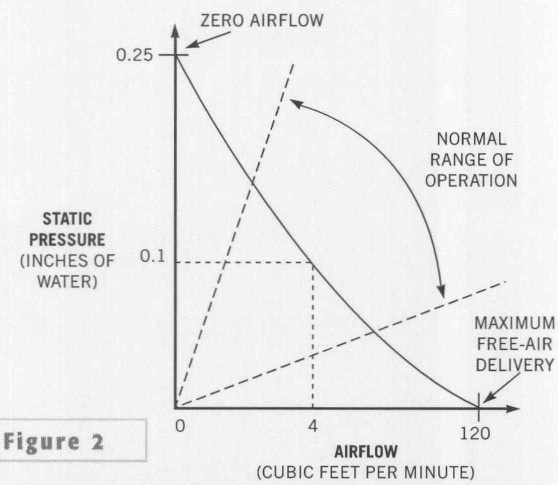


Figure 2

You can use a fan's airflow-versus-pressure difference curve to determine whether the fan will provide adequate cooling in your application.

In a sample calculation, a system uses 70% of a single ac/dc 400W power supply's output that operates at 75% efficiency—that is, the supply contributes 25% of its output as heat. The system's fan or fans must remove all of the resultant waste heat, as follows: $P_{DISS}=125\%\times400W=500W$; $70\%\times500W=350W$. Design the system for operation in ambient air that's no hotter than 35°C (95°F). The system's heated exhaust air must not exceed a worst-case temperature of 50°C (122°F), producing a temperature difference, T_D, of 15°C. Next, calculate n, the effective airflow required, in units of cubic feet/minute: $n(cfm)=k\times P_{DISS}/T_D$, where $k=1.757$ cfm×°C/W. Solving for n yields: $n=1.757$ cfm×°C/W×350W/15°C= 40.99 cfm.

Select a fan and examine its pressure versus-airflow-volume curve (**Figure 2**). At an airflow of 41 cfm, the fan's static pressure curve shows 0.1 in. of water within the fan's normal operating range. (For additional information on fans and their characteristics, see **Reference 3**.)□

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Spreadsheet converts sound levels

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As everyone who attempts to get someone's attention from a distance intuitively knows, sound level decreases as the distance between the source and the detector increases. For distances less than 50 ft, the rule of thumb states that sound level drops 6 dB for every doubling of the distance between the sound source and the detector.

If your work involves generation of audible signals, the rule of thumb may appear simple, but putting it into practice takes valuable time to ensure that you correctly calculate the conversion. To complicate matters, there's no standard single distance for measuring sound level, and thus conversion of sound levels for different separations or between metric- and nonmetric-measurement units requires rethinking and recalculation.

For example, if an audible signal source measures 90 dBa at a distance of two feet, what's the equivalent sound level at a distance of 10 cm? If you can perform this conversion without putting pencil to paper, you're several steps ahead of your competition. To ease sound-level conversions, you can use an Excel spreadsheet (available for downloading at the online version of this Design Idea at www.edn.com). You enter a sound level in decibels acoustic, and the calculation returns sound levels for various commonly used measurement distances.□